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Market Assessment of Public Sector Energy Efficiency Potential in India

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Disclaimer

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Executive Summary

Between 1990 and 2005, energy consumption increased by over 60% in the commercial building (including both public[1] and private) sector. Key drivers affecting energy use and related emissions of the sector include population and economic growth, extreme temperatures, and energy prices. Space cooling and lighting are the two primary end-uses for the sector contributing to the overall energy use.

In 2001, the Indian government enacted the Energy Conservation Act (ECA 2001), which promotes energy efficiency and conservation in the country. ECA 2001 mandated the creation of the Bureau of Energy Efficiency (BEE), which was established as an independent agency under the Ministry of Power in 2002. ECA 2001 also authorized BEE to establish an Energy Conservation Building Code (ECBC), along with developing and implementing standards and labels for energy consuming devices. ECBC is currently voluntary, but in the future, either the central and/or state governments may decide to adopt it as a mandatory standard. BEE's commitment to reducing the energy intensity of the economy through policy initiatives and other energy efficiency service and delivery mechanisms in the buildings sector has been impressive, however, a substantial amount of additional energy- and carbon-saving benefits will be difficult to realize in the absence of a better understanding of the efficiency market and potential in the commercial buildings sector.

The purpose of this study is to assess, with limited resources, the potential for improving energy efficiency in public buildings by providing preliminary estimates of the size of the public sector buildings market, the patterns of energy use in public buildings, and the opportunity for reducing energy use in public buildings. This report estimates the size of this market and the potential for carbon savings with conservative assumptions requiring moderate investment towards efficiency improvement in public sector buildings– here defined as the sum of the public sector commercial and institutional buildings as characterized by the Ministry of Statistics and Program Implementation (MOSPI). Information from this study will be provided to the World Bank and the BEE to assist them in designing effective energy efficiency programs for public buildings.

The estimate of the size of the public buildings market in India is approximately 220 million square meters spread over two million buildings, as of 2005. The source for this estimate is the Economic Census of India 2005 and studies on space utilization in buildings. The limitations of this estimate are the uncertainties due to non-uniformity in space utilization across regions and building types.

[1] Public buildings as defined in this report include establishments that are either owned or occupied by the government or a government undertaking. These include buildings under the central government, the state governments, and local municipalities. Publicly owned institutions and organizations such as banks, co-operatives, educational institutions, health facilities, scientific and research establishments, sports facilities, and tourism and hospitality establishments, and government residential complexes are also part of this sector.

Sixteen percent of the non-residential building stock (number of buildings) in India is owned and operated by the public sector and it represents 30 percent of the non-residential building floor space. Public building stock includes schools, research establishments, offices, hospitals, community centers, post and telecommunications providers, and some retail trade.

Public offices, schools and hospitals represent most (85%) of the public building floor space. Schools and public office buildings comprise approximately one-third each of the public building floor space and public hospitals represent the remaining 15 percent. Space conditioning (primarily air conditioning) and lighting are the largest sources of energy use identified in this analysis. Among buildings surveyed, 5 percent of schools, 30 percent of offices, and 80 percent of hospitals currently have air conditioning – cooled space even in buildings with air-conditioning is likely going to be less than 50%; with rising incomes, the energy requirement for additional space conditioning is expected to increase.

For the future, Indian public building floor space is expected to double by 2050, with large offices, healthcare facilities, and schools showing the largest increases (36%, 28% and 17% respectively of total new building space). By 2030, about half of the buildings are those in today's stock, with the portion declining to about a third in 2050. The effects of modernization, with increased space conditioning and lighting loads, are reflected in the corresponding projection for total electricity consumption, which, absent intervention, is expected to more than triple from 9 TWh in 2005 to 33 TWh in 2050.

The estimates of energy use in public buildings is based on size of the building stock and energy use intensity estimates from the survey data used in this study because there are no official estimates of energy use in public buildings. The study utilized specific case studies available in the public domain and collected additional data from public sector buildings. The limitations of this approach are the uncertainties associated with the building stock estimates, which could have a ±10-15% variation. Furthermore, a limited dataset for estimating energy usage at the building level may introduce an urban bias and is not sufficiently large to produce statistically robust estimates of aggregate energy use intensities.

Our study addresses first the issue of establishing energy use baselines for the public sector buildings. This approach establishes the "business as usual" (BAU) case, and enables the study to develop a realistic scenario of efficiency improvements termed the "High Efficiency" (HE) case. BAU is represented by existing pattern of energy consumption in the sector being maintained over the 2010-2050 period. The HE case is represented by applying aggressive, but plausible, market penetration scenarios to the techno-economic potential of the technologies analyzed.

The analysis indicates that energy use in public buildings is 9 TWh in 2005 and is dominated by lighting, HVAC, and office equipment. The options for reducing energy use in public buildings include cost-effective savings of at least 9% through improvements in selected technologies for space cooling and lighting for replacement in existing buildings and new construction in hospitals, offices, and schools.[2] Analyses based on more comprehensive data, e.g., with inclusion of building envelopes and chillers, should they be collected, are likely to identify larger opportunities to reduce energy consumption, greenhouse gas emissions, and electricity costs.

With conservative assumptions on efficiency improvement, our analysis shows a potential annual energy cutback of 3 TWh by 2050, which is a 9% reduction in total energy consumption for the sector. In terms of annual emissions reduction, the considered measures yield about 3 MT of annual CO_2 savings by 2050, which is a 9% reduction for the sector just from two end-uses. The estimated savings amount to a cumulative reduction of about 20 MT of CO_2 over the period 2010-2020 and 80 MT of CO_2 over 2010-2050. The savings estimates are conservative accounting for select end-uses due to limited data on current energy use and existing mix of technologies. The measures considered translate into an annual investment of capital investment of about $50 million over 2010- 2020 and about $100 million annual, over 2020-2050 periods.

Future analysis can refine these estimates and provide additional information. Possible activities to build on this work could include expanding and solidifying the data collection effort by filling the gaps and creating a more representative energy use profile for buildings. Building on the ongoing periodic collection of data in the residential sector, the Indian government would benefit from pursuing a similar program in the commercial buildings sector. The data collection could focus on building characteristics, energy use, location, and type of equipment that are used for lighting, cooling and other energy end-uses. In addition, research on market and technology characterization for specific end-uses such as building envelopes, cooling systems, and lighting technologies will allow policy makers to tap into additional opportunities for savings.

[2] In hospitals, offices, and schools, lighting and air-conditioning end-uses together are estimated to account for 25, 30 and 50 percent of their total energy consumption respectively. In this study we consider improvements in selected lighting and cooling technologies for which data were available. The selected technologies are estimated to account for 10 – 50 percent of installed cooling technologies, and 20-80 percent of installed lighting technologies in different building types. The cost-effective efficiency improvement potential for selected technologies is in the range of 17-22 percent in air-conditioning and 20-40 percent in lighting for different building types. The aggregate 2050 savings potential for replacement and new hospitals, offices, and schools is 8%, 13%, and 6% respectively or an average of 9%.

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Market Assessment of Public Sector Energy Efficiency Potential in India

1. Introduction

Buildings are the second largest contributor to greenhouse gas (GHG) emissions, accounting for approximately 20% of the total CO_2 emissions in India (WRI 1999). Significant GHG emission reductions can be achieved from the built environment through the design and construction of new green buildings as well as the sustainable operation and renovation of existing buildings. Government owned buildings and other public sector buildings[3] account for over 30% of the existing stock of commercial floorspace in India, and consequently a significant proportion of energy use. Building energy consumption accounts for a significant fraction of the total electricity consumption. While much of the share belongs to consumption in the residential sector, the commercial sector, including public buildings, accounts for a more rapidly increasing component of total electricity use. The resulting carbon dioxide emissions are also significant. Increasing urbanization is one of the key drivers of new construction and energy consumption in the country.

Considering the vast potential of energy savings and benefits of energy efficiency, the Government of India enacted the Energy Conservation Act, 2001 (52 of 2001). The Act provides for the legal framework, institutional arrangement and a regulatory mechanism at the Central and State level to embark upon energy efficiency drive in the country. However, there is little guidance or existing framework for basing the efficiency improvements or implementation programs that focus on improvements in commercial buildings. There have been several independent studies and energy audits performed on specific buildings, but there is very little by way of integration of these efforts.

This study tries to bring together the individual and separate efforts already underway, and creates an integrative framework to establish baseline energy consumption and energy use-intensities for specific building types. This information can help users and other stakeholders including builders, architects, code enforcing agencies to evaluate building energy efficiency and track improvement compared to other buildings. The information is also critical for setting benchmarks that can be used for ECBC compliance, labeling of existing buildings, and recognizing the top performers through a systematic evaluation scheme. As one of the outputs, the study created a data collection template in consultation with the ECO III project office. The template is a good starting point to integrate the existing audit data and to regularize data collection on building characteristics and energy use.

[3] In this study, public sector buildings are defined as establishments that are either owned or occupied by the government or a government undertaking. These include buildings under the central government, the state governments, and local municipalities. Publicly owned institutions and organizations such as banks, co-operatives, educational institutions, health facilities, scientific and research establishments, sports facilities, and tourism and hospitality establishments are also part of this sector.

As one of the key objectives, the study also explores possible approaches to estimating the total stock of public buildings and characterizing the energy savings potential in that stock for space cooling and lighting, which are the two major end-uses in the sector.

The report is structured as follows. In this section, we provide background information and the methodology used to make these estimates. In Section 2, we describe the characteristics of commercial buildings and describe recent and current initiatives to collect data and energy efficiency projects in the public sector. Section 3 reports on the data that was collected and used in this study including LBNL survey data for selected buildings across India. Section 4 reports on the results of the estimates for efficiency improvement potential and carbon emissions savings and investment requirement. This is followed by the concluding section.

1.1 *Background and Objectives*

As per the 17th Electrical Power Survey (EPS) of the Central Electricity Authority, the electricity demand is projected to increase by about 40% by 2012 over a five year period, and double over the subsequent decade reaching approximately 1900 TWh by 2021-22 (MOP 2007). The EPS's forecast is consistent with the growth in consumption across sectors in the recent past. Specifically in the buildings sector, the country has seen a near consistent 5% rise in annual energy consumption in the residential and commercial sectors. In 2004-05, residential and commercial sector together consumed about 135 TWh of electricity from the grid. Figure 1-1 presents the trend in sectoral electricity consumption. Building energy consumption has seen an increase in its share of 15% in the 1970s to nearly 33% in 2004-05. The growth has been particularly pronounced in the commercial sector with a growth rate of 8%. The 17th EPS forecasts an annual growth of 10.5% in the commercial sector over the next 5 years. Electricity use in both residential and commercial sectors is primarily for lighting, space conditioning, refrigeration, appliances and water heating.

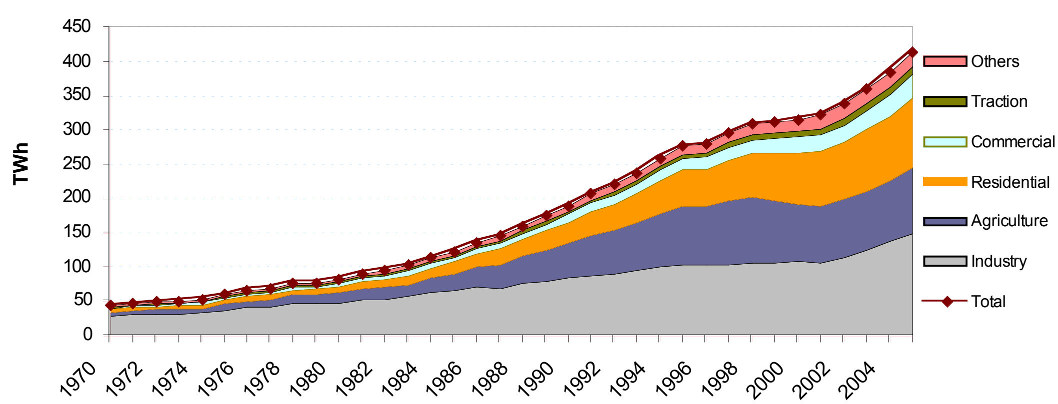

Figure 1-1. Trend in Sectoral Electricity Consumption in India

As is also evident from looking at the construction sector, its contribution to total GDP has been rising rapidly since the past few years. In 2006–07, the sector registered an increase of 10.7% from the previous year. The share of the construction industry has grown significantly as is visible from Figure 1.2 below and is reflected in the share of construction in GDP, which has increased from 6.1% in 2002–03 to 6.9% in 2006–07. The reason for increased construction activity can be attributed to both an increased demand for residential, commercial and institutional spaces. Overall, the contribution of the sector has increased to 10.8% during the Tenth Five Year Plan from 7.5% during the Ninth Five Year Plan. Consequently, the projected investment in infrastructure in the Eleventh Plan is more than double the amount in the Tenth Plan (GOI 2008).

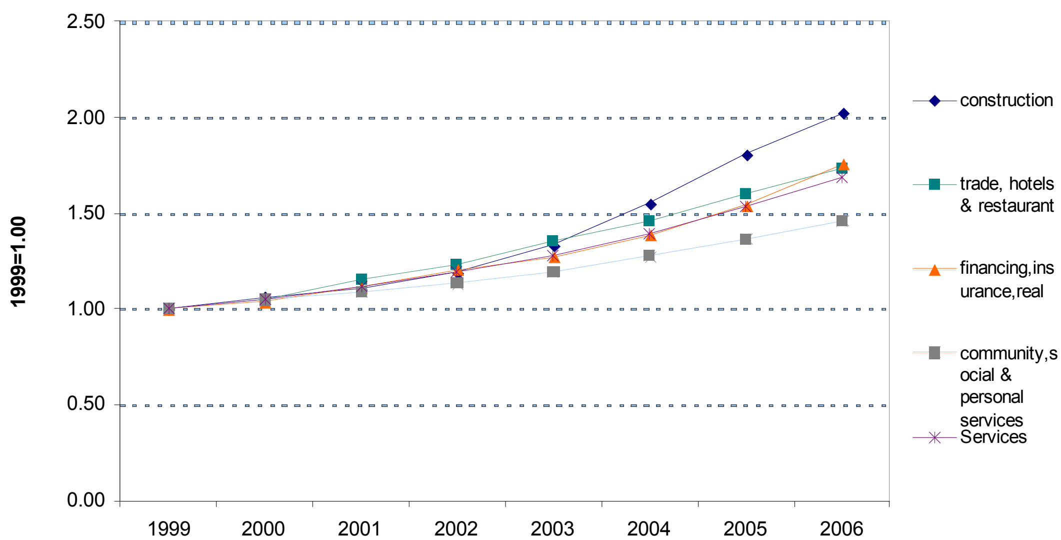

Figure 1-2 Trend in Value Added from the Indian Service Sector

Figure 1-3 shows the growth in new construction over eight years.

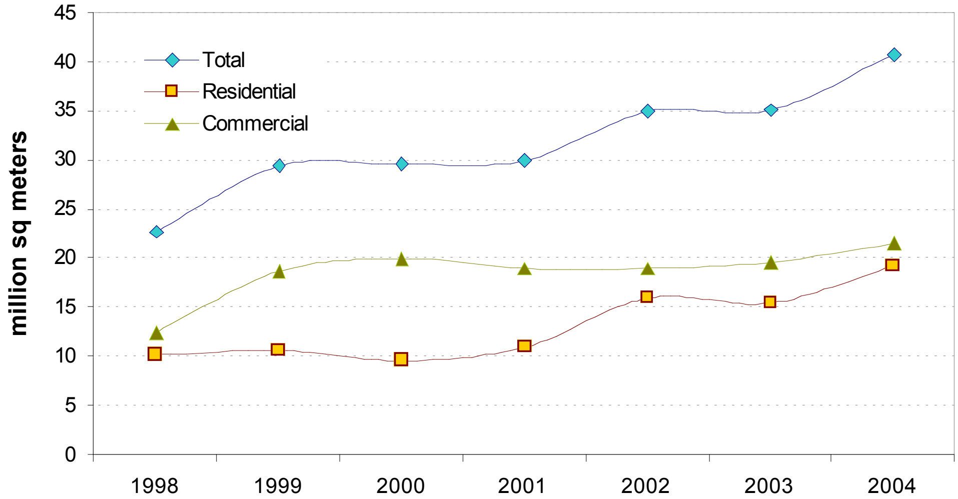

Figure 1 -3 Trend in New Construction

As per the estimates from the Construction Industry Development Council (CIDC), the total new construction floorspace added in the commercial and residential sectors was about 43 million square meters in 2004-05, of which about 23 million square meters is in the commercial sector. The new construction trend shows a consistent annual growth rate of about 10%. The Gross Fixed Capital Formation (GFCF) shows a similar trend with over 18% annual growth in the non-residential buildings during 2000-05, with bulk of the growth taking place in the private sector (MOSPI 2008). These numbers also point to an expectation that commercial sector construction will see a consistent growth in the next 5-10 years. It is therefore clear that commercial building stock will play a significant role in overall electricity consumption in the country.

Buildings in the public sector form a large portion of the commercial building stock in India. The public sector is also a major purchaser of energy, energy using equipment, besides owning and managing a number of buildings and overseeing their operations. Given its relatively large size, this sector presents a unique opportunity to study the savings potential from implementing specific efficiency measures. In addition to the scope for improvement, the public sector also has a leadership role in demonstrating or leading by example towards a greener and more energy efficient path.

1.2 *Methodology and Scope of Study*

For the purposes of this study, public sector buildings of all sizes are considered, from both rural and urban environments. Industrial buildings and multi-unit residential buildings are excluded to remain consistent with the definition used by the MOSPI (Ministry of Statistics and Program Implementation). The research and analysis contained in the report focuses on the energy consumption and carbon emissions generated during the operational life of the building since 45 – 80% of energy is consumed during this phase[4] (Thormak 2002). Construction and demolition phases of the life cycle are excluded from the analysis.

The main scope of the study comprised an estimation of the current commercial building stock with a reasonable sense for the proportion of public sector building and their distribution across activity types. At the next level, the study aimed to profile energy consumption in public sector buildings. Understanding energy use is essential to identifying potential saving opportunities in this sector.

The research and analyses supporting this study have three major components:

1. Collaborative Data Collection and Consultation: LBNL formed a collaborative partnership with the ECO III project office in India to review existing building energy use information, inform the project of the general construction and design processes, and identify areas for increasing efficiency of operation. Collaborating with ECO III, LBNL established links with agencies that own or operate buildings. These agencies include the Central Public Works Department (CPWD) and Bharat Sanchar Nigam Limited (BSNL). Individual stakeholder consultations were also used to inform the process.
2. Data Collection: The study utilizes existing energy audit data and additional building data to profile public sector buildings. It describes the energy performance characteristics in public buildings for specific segments of the Indian public building population. We estimate the current building stock and forecast the likely growth of the stock in this category of commercial buildings. Data was compiled from both primary and secondary sources. The secondary sources include BEE, CSO, ECO III, DSCL, and a range of Indian and international publications. LBNL also worked with architectural firms in India to collect building level data to profile energy consumption across building types and to assess the technology mix of the equipment used in buildings. These data were used to develop assumptions about the anticipated policy impacts on energy efficiency in commercial buildings for the economic modeling component of the report.
3. Modeling: The main driver of sector energy is economic growth. The World Bank's forecast has GDP growth at 8% till 2021, after which it drops to 7.5% till 2026, and 7% till 2030. The main forecasting effort is to establish levels of activity that result in energy demand. For the buildings, the main activity variable is floor area, which will be affected by increases in GDP. The methodology takes a bottom-up and demand-side approach. The model is structured in sufficient detail to capture realistic efficiency options at the end-use level. Consultations and literature reviews were used to develop an efficiency scenario. The model projects forecasts impacts of the policies on energy efficiency technology deployment in India's commercial buildings under two scenarios:

[4] The proportion of energy used during the operational life of a building is based on the level of conditioning in the building.

a. Business As Usual (BAU) – This examines the consequences of continuing current trends in population, economy, and improvements in technology/efficiency;
b. High Efficiency (HE) – This examines the effects of cost-effective policy measures mainly in space cooling and lighting end-uses on the overall consumption for the sector.

As a means to enhance the data collection process, we include a plan/template for collecting data in Appendix B.

2. Commercial Building Characteristics and Current and Recent Initiatives

The non-residential or the service sector includes activities related to public administration, health, education, real estate, banking and finance, trade, and other services. Understanding energy consumption by this sector requires a reasonable sense of the share of the various activity types, building characteristics and detailed data on end-use equipment. Energy use in buildings is affected by the physical characteristics of the buildings, including building design, choice of location, structure and layout, as well as the efficiency of the equipment and the occupants' energy-related behavior. Specifically, the two most important parameters that determine the energy use in this sector are the building floorspace and the end-use technologies in place. These two measures provide different aspects of commercial building use, which allow energy analysis to focus on the characteristics of building use as they relate to either the building stock or the amount of floorspace.

2.1 *Characteristics of Commercial Building Sector and Public Sector Buildings*

Information at this level in India is very limited. There is no single source of data that provides an estimate of the building stock as a whole or by building types. The National Buildings Organization (NBO) under Ministry of Urban Employment and Poverty Alleviation is tasked with collecting and disseminating the building construction statistics. The organizational information suggests that the collected data includes current housing and building construction activity both from public and private sectors. In addition, NBO also collects data on building permits and completion certificates issued during a year from all towns with a population of 100,000 or more. This data would be useful to establish more accurately the new construction trend for forecasting purposes. At present, publications containing data are not readily available and thus, our study is unable to make use of it. It would be useful to incorporate these studies for improving the assumptions of this study and evaluating more aggressive efficiency measures in the sector in the future.

The Government of India conducts periodic economic census that provides a comprehensive account of major economic activities and their characteristics (MOSPI 2006). The scope of the census includes principal characteristics of the establishments and employment classified by major activity groups, type of establishments, ownership type, size class of employment, fuel used, source of finance, etc. The last economic census was conducted in 2005. The economic census data also categorizes employment statistics and establishments into those belonging public, private, and NGO sectors of the economy. In the absence of any official estimates of commercial building stock, we relied heavily on the economic census data to come up with rough preliminary estimates of the size and stock of the commercial building population. The economic census also provides disaggregated establishment and employment data by states, which may be used later for estimating regional or climatic distribution of buildings. Our study uses data from this publication and space utilization[5] rates to come up with a rough estimate of the existing building floor area and building stock by various economic activity groups.

Figure 3-4 presents the distribution of buildings across economic activity groups. This exercise puts the current stock of commercial buildings across India at about 12.5 million, of which about 16% are in the public sector.

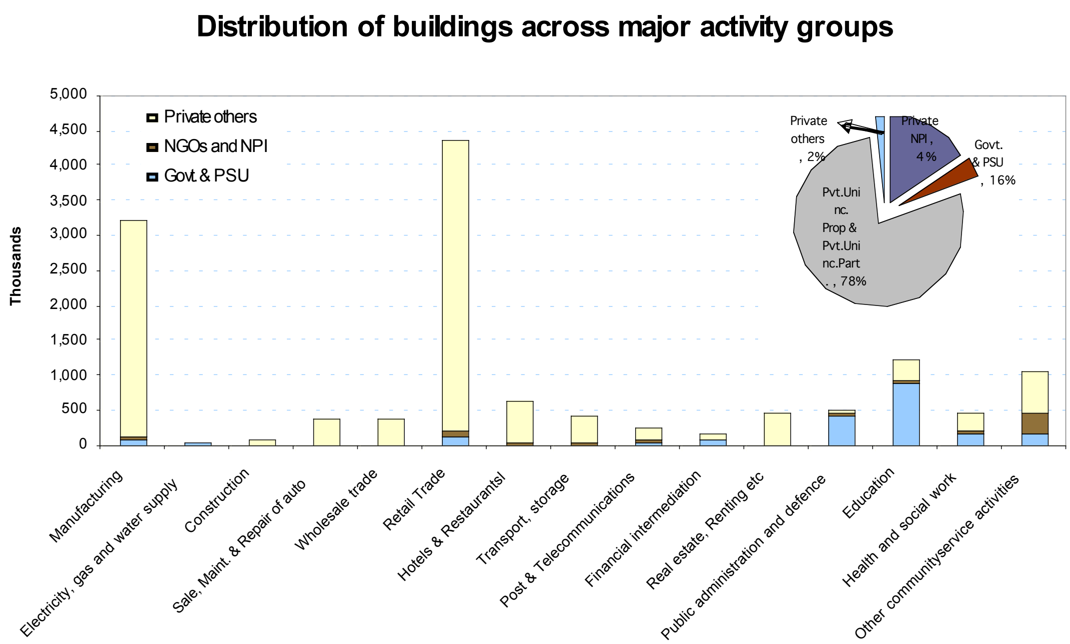

Figure 2-1 Building Stock by Activity Type

We map the data further to specific building types in order to estimate the total commercial floorspace by building type. The following figure represents the estimated floorspace distribution by building type in the public sector. Of the total commercial

[5] We use space utilization factor from several sources, including Commercial and Industrial Floorspace Utilization Survey (CIFUS) from Hong Kong, code specifications, and discussions with experts. Assumptions on Space Utilization factor will be provided in the Appendix.

floorspace in the country, we find about 30% to be under public sector ownership. The distribution further indicates that schools and offices account for the largest share of total floor area followed by health care and other services. From the perspective of ownership, bulk of the schools is in the public sector or government, while offices and health have an equal proportion in the public and the private sectors. In the following sections, we will look further into government offices, and hospitals, as these two building types are major contributors to the overall energy consumption in the public sector and thus present a significant opportunity for energy savings.

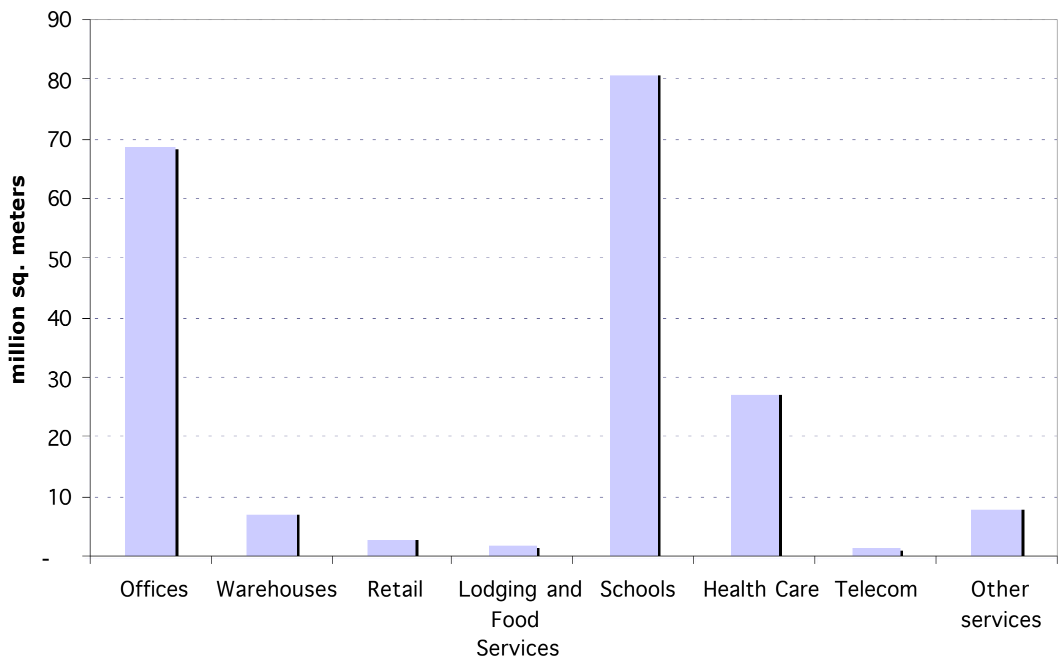

Figure 2-2 Distribution of Floorspace in Public Sector Buildings

Government Offices

The characteristics of office buildings are of increasing interest from the energy perspective since office buildings account for over a fifth of all energy used in commercial buildings in most countries. The share of energy consumption is a function of the total floorspace they account for in the commercial sector.

Estimates based on the Economic Census of India (GOI 2005) illustrate that offices account for about 35% of the total building floorspace in the country. The same estimate indicates that about 50% of the office floorspace is within the Government or Public Sector purview. In the public sector, offices account for more than a third of the floorspace. In the year 2006-07, the public sector, comprising administrative departments, departmental enterprises and non-departmental enterprises, contributed 21.4 per cent to the GDP and 22.3 per cent to gross domestic capital formation. Figure 3-5 shows an estimated office market of about 70 million sq. meters to be under government or public sector ownership. In bigger cities, about a third of the office space can be classified as Class A or B space[6]. Most of the newer construction in this sector will fall in Class A or B category.

Hospitals

Estimates based on the Economic Census of India (GOI 2005) illustrate that hospitals account for about 27% of the total building floorspace in the country. Of this, we estimate about 50% to be within the Government or Public Sector purview. As per the Central Bureau of Health Intelligence's National Health Profile, the total number of government hospitals in the country is 9,976 (GOI 2007).

National level energy consumption data in healthcare facilities is not available in the public domain. Nevertheless, estimates based on ECO-III study indicate a wide range in energy use pattern across hospitals based on their urban-rural setting and private or public ownership. The following table from the ECO-III study presents the electricity consumption.

Table 2-1 Estimated Electricity Consumption in Hospitals

Hospital	No. of Beds	Estimated (kWh/Bed/year)
Government Hospitals - Urban	328,491	750-1500
Government Hospitals - Rural	154,031	150-300
Private/NGO Hospitals and Nursing Homes	500,000	1000-2000
Total	982,522	-----
Source: USAID ECO-III Project, 2009		

2.2 *Energy Audits and Energy Service Initiatives in Commercial Buildings*

In 2001, the Indian government enacted the Energy Conservation Act (ECA 2001), which promotes energy efficiency and conservation in the country. ECA 2001 mandated the creation of the Bureau of Energy Efficiency (BEE), which was established under the Ministry of Power in 2002. Under the direction of the Prime Minister, the government's Planning Commission issued the Integrated Energy Policy in 2006. Five of the thirteen areas are related to the buildings sector, including building design, construction, HVAC,

[6] Class A and B office buildings are characterized by a high construction quality. Typically, Class A buildings in India will have space conditioning and a 24-hour power back-up.

lighting and household appliances. Some of the salient ongoing initiatives are summarized below:

a. Energy Conservation Building Code 2007

In May 2007, the Ministry of Power and BEE issued ECBC —the first stand alone national building energy code in India. While it is currently voluntary for all buildings with a connected load of 500 kW, ECBC establishes minimum energy efficiency requirements for building envelope performance, lighting, HVAC, electrical system, water heating and pumping systems. To develop ECBC, BEE collaborated with a diverse group of domestic and international technical experts; In July 2009, the Delhi Cabinet approved a proposal for implementation of the ECBC in new government buildings/building complexes. With this, ECBC will become mandatory for new public sector buildings.

Box 1. Energy Conservation Building Code (ECBC)

The development of ECBC had participation of four major stakeholders including Building Users, Government and NGOs, Industry and Financing institutions. ECBC was developed based on extensive data collection and analysis of building types, materials, and energy consuming HVAC and lighting equipment commonly used in India. The code is designed to include climate variability. ECBC categorizes India into five climatic zones for building design. The Base case models were then developed for buildings in these climate zones with identification of options for energy conservation in different building systems including envelope, lighting, HVAC, and water heating. BEE aims to make ECBC mandatory for all new buildings that have a connected load greater than 500 kW or a contract demand of or higher than 600 kVA. The code is also applicable to all buildings with a conditioned floor area upwards of 1,000 square meters.

The provisions of ECBC

The building code has provisions for

1. Building envelopes, excluding unconditioned storage spaces or warehouses,
2. Mechanical systems and equipment, including heating, ventilation, and air-conditioning,
3. Service hot water,
4. Interior and exterior lighting, and
5. Electrical power and motors.

The provisions of this code do not apply to:

1. Buildings that do not use either electricity or fossil fuel,
2. Equipment and portions of building systems that use energy primarily for manufacturing processes, and
3. Multi-family buildings of three or fewer stories above grade, and single-family buildings.

b. ECA 2001, and Commercial Buildings as 'Designated Consumers' (DCs).

One of the roles envisaged for BEE under the ECA was to specify energy consumption norms for energy consuming industry. ECA identifies commercial buildings as a "Designated Consumer". In February 2009, BEE launched the Star

Rating program for Office buildings with expectation that the rating system would create a demand in the market for energy efficient buildings based on actual performance of the buildings in terms of specific energy usage. This rating program has been launched as part of the national commercial energy benchmarking initiative, which was initiated with a goal to establish a framework to standardize energy data collection, baseline setting for a prototypical commercial building with a view to improving energy performance of buildings (BEE 2009).

c. BEE's initiatives in promoting energy audits in Government Buildings in Delhi
At the national or state level, end-use level energy consumption is not available for buildings either at the aggregate or by building type. The requirements include Central and State level enforcement provisions with respect to conducting energy audits by accredited energy auditors in the existing buildings, appointment of energy managers, and reporting of energy consumption and conservation by DCs. As part of the mandate contained in ECA 2001, BEE initiated the Energy Efficient Government Buildings program. The program completed energy audits of 9 public buildings during Phase I of the program. Subsequently, 17 additional buildings were selected for energy audits in Phase II of the program by way of performance contracting through ESCOs

Based on the audits conducted in several government buildings, studies estimate an overall energy savings potential of 760 GWh per annum (Singh and Michaelowa 2004). The same studies also estimated that air conditioner facility improvement will require about 80% of the total investments whereas lighting will require 10% of the investments.

Box 2: Energy Audits of Government Buildings – A Case Study

Nine government buildings and establishments including the *Rail Bhawan, Sanchar Bhawan, Shram Shakti Bhawan, Transport Bhawan, Research & Referral Hospital, Terminal I, II* and cargo section of *Delhi Airport, Prime Minister Office, Ministry of Defense Blocks, Rashtrapathi Bhawan* and *All India Institute of Medical Sciences* have been identified for the project. Below, we summarize the energy audit and recommended measures for efficiency improvement for one government building.

Shram Shakti Bhawan

The *Shram Shakti Bhawan* is located in central Delhi under New Delhi Municipal Council (NDMC) administered area. The metering of *Shram Shakti Bhawan* includes the electrical supply to *Transport Bhawan* as well. The total floor area of the six-storied *Shram Shakti Bhawan* is building is 2356 M^2. *Transport Bhawan* is a five-storied building with a total floor area of 2280 M^2. The buildings have a connected load of 1.8 MW; annual average consumption is 2.1 GWh. The current consumption shows the share of lighting to be 28% and that of air conditioning to be 44% of the total electrical energy, respectively.

Area	Brief Description	Savings, US$	Investment, US$
Lighting	Retrofit based on Design and Technology for task lighting	18,533	26,222
Air Conditioning	Replacement of Window and Split ACs with Centrifugal Chiller based Central AC System	59,556	271,111
Total		78,089	297,333

The audit suggests a total energy savings potential of 26%.

d. *Energy labeling of appliances*

BEE has several programs to set labels and energy efficiency standards for refrigerators, air conditioners, motors and other appliances. Labeled products have been in the market since 2006. In a move to manage energy demand, BEE has proposed to make star rating for energy efficiency mandatory for a host of electrical appliances from September 20, 2008. The implementation of this mandate is yet to be seen;

e. *The Ministry of Environment and Forests (MoEF), Environmental Impact Assessment (EIA) and Clearance.*

This is a mandatory requirement for all buildings with a built up area above 20,000 sq. m and such projects have to be apprised by the MoEF's Environmental Appraisal Committees (EACs) and the State Environmental Appraisal Committees (SEACs).

f. *Initiatives taken by CII, TERI and others in promoting energy audits and energy efficiency in existing buildings;*

There are several institutes that have been engaged in promoting energy efficiency in commercial buildings and have formulated green building ratings. The country currently uses two rating systems – CII-IGBC's LEED and TERI's GRIHA. CII-IGBC is facilitating the LEED rating of the U.S. Green Building Council (USGBC) in India. LEED-India was launched in 2001 and rates buildings on environmental performance and energy efficiency during the design, construction and operation stages. Green Rating for Integrated Habitat Assessment (GRIHA) was jointly developed by TERI and the Ministry for New and Renewable Energy as a national rating system for commercial, residential and institutional buildings. The GRIHA rating system takes into account the provisions of the National Building Code 2005, the ECBC 2007 announced by BEE and other IS codes. The rating system was developed specifically aimed at non-air conditioned or partially air conditioned buildings.

g. *DSCLES and ECO-III Partners' Experience in different sectors;*

As part of providing technical assistance to the states of Punjab and Gujarat in implementing their state level energy conservation plan, the ECO-III project office in partnership with DSCLES compiled data on several state and private buildings. The building level data collected included specific information on building characteristics and energy use patterns. The data included about 80 public sector buildings, which were made available to this study.

h. *The Indian National Action Plan on Climate Change (NAPCC)*, released in 2008, charts the likely future direction of energy efficiency policies. The plan names "enhanced energy efficiency" as one of eight key missions to address the impact of climate change in India. The proposed strategies aim at promoting efficiency in residential and commercial sector through various measures such as, change in building bye laws, capacity building, research and development in new technologies, education and awareness, etc., management of municipal solid wastes, and promotion of urban public transport. The mission also proposes initiatives to accelerate the shift to energy efficient appliances through tax incentives (such as an accelerated depreciation of up to 80 percent in the first year and a lower VAT on EE equipment), mechanisms to help finance demand side management (DSM) programs in industrial sectors, and innovative financial instruments to enhance energy efficiency. Most importantly, the plan recommends mandating lower energy consumption in large, energy-consuming industries and facilities and the establishment of a market-based mechanism to make energy efficiency programs more cost-effective. This would be done by certifying energy savings above those mandated and enabling the companies to trade their excess savings.

i. *Developing a Standardized Building Energy Assessment Manual and Benchmarking Framework*

BEE has initiated a commercial energy benchmarking initiative at the national level. Some of the key goals of this initiative are to establish a standardized framework for energy data collection, baselining energy use in a typical commercial building, and target setting for efficiency improvement. As part of developing standardized benchmarking, inn February of 2009, BEE launched its Star rating for office buildings. BEE expects that the Star rating program would create a demand in the market for energy efficient buildings. Initially, the program targets three climate zones – Warm and Humid, Composite, and Hot and Dry. BEE hopes to extend the scheme to other climate zones in future. Under the same initiative, the State Development Agencies have been directed to collect energy use information at building level.

j. Establishment of Building Energy Efficiency Centers and Cells

In September 2002, DSM cells were set-up in utilities in five states and pilot projects had been designed for Karnataka and Maharashtra. Through 2002-03, capacity building exercises were initiated and completed in MEDA (Maharashtra Energy Development Agency) and BESCOM (Bangalore Electricity Supply Company). Ever since, additional capacity building exercises for the electric utility regulators as well as the preparation of investment grade feasibility reports for implementing DSM projects have been underway.

Few energy end-use sectors in India are gradually adopting newer technologies and management techniques to improve energy efficiency. However penetration of these in at the national/sectoral level has remained slow. Keeping this in view, ECO-III, has taken initiative to establish Regional Energy Efficiency Centers (REECs) mainly to equip them to provide public education and awareness, facilitate demonstrations (showcasing products), promote technology development (incubation), and catalyze energy efficiency amongst the energy end-users and general public at large. With support from Asia-Pacific Partnership, ECO-III is supporting three REECs focusing on Domestic Appliances, Buildings and Industrial Furnaces of SMEs. Initial funds for starting up the centers are being provided by APP under the Project. However, REECs in an effort to become self sustainable in the longer run, plan to diversify their funding from multiple sources through public-private partnership

k. LBNL's data collection effort on Public Sector buildings

In order to get a better representation of all the building types and to gain a more comprehensive coverage of the climate zones, LBNL commissioned a few architectural firms in India to collect data on physical characteristics for a set of commercial buildings that captured building use and occupancy patterns, equipment and energy use in buildings. The effort yielded data on about 30 public sector buildings.

3. Data Used in the Study

In order to analyze the savings potential, the study needed to baseline energy consumption of public sector buildings. This exercise required a set of buildings to profile building characteristics and energy use. LBNL created a sample set of buildings for this purpose, utilizing energy audits commissioned by BEE/GOI, data collected by the ECO-III project office, and LBNL's own effort to collect building level data through architectural firms based in India. This enabled the study to compile data on building characteristic and energy use for a total of 130 buildings that were owned and operated by the public sector in major metropolitan areas of India.

The information gathered includes data on several owner and occupancy characteristics, physical building characteristics, types of energy technology in place, percentage conditioned, and energy bill information. The figure below shows the distribution of these building records across activity type and climate zones. Bulk of the compiled building data is in the category of offices followed by hospitals and educational institutions and, hotels. This spread is reasonably representative of the distribution of the country's public sector building stock across activity types. A similar distribution is presented for the sample across climate zones. The temperate zone is somewhat under-represented in this sample, due to lack of building data from that region. The sample is fairly representative for the remaining 4 climate zones.

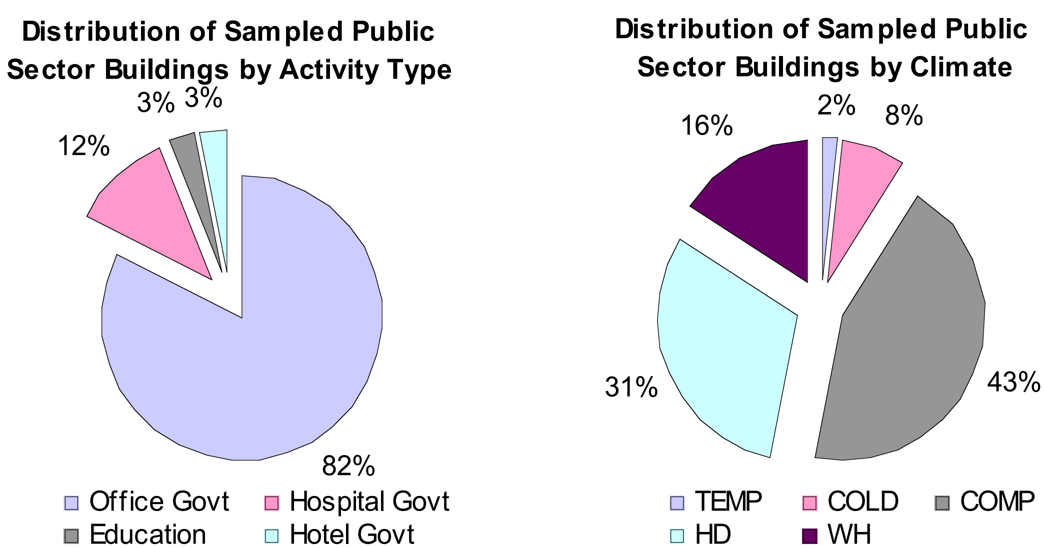

Figure 3-1 Distribution of Sampled Buildings by Activity Type and Climate

3.1 *Activity Variables*

The main forecasting effort is to establish levels of *activity* that result in energy demand. In the case of buildings, the main activity variable is *floor area*. The other activity variables that are used for estimating energy savings potential from the public sector are climate variability, equipment use and penetration, and hours of operation.

Floorspace:

At an aggregate level, new construction will be driven by economic activity, and urbanization. In general, we model floor area either as a function of the size of the economy or by forecasting construction as a function of economic growth. For specific sub-sectors, the factors driving the current rapid economic growth, such as retail and offices, floor area is modeled in terms of the contribution of the construction sector to the overall service sector GDP. Construction of government office buildings is expected to track with overall GDP of the country. In less dynamic sectors, such as education and health sectors, total floor area scales with population and/or per capita GDP. We take the number of beds per capita to be a proxy for health services overall. Health sector floor area is thus assumed to scale with the number of hospital beds. Education, on the other hand is assumed to scale by education levels – number of students enrolled in primary, secondary and post-secondary education. Additions in floor area implied is important, since new construction is expected to have different energy intensity properties, both in the business as usual, and in the policy scenario.

Climatic zones:

India has a reasonably diverse climate, ranging from extremely hot desert to high altitude locations with severe cold conditions, and therefore different energy usage patterns and demand. On the basis of hourly temperature, various climatic parameters and solar radiation data recorded at 233 weather stations, BEE divides the country into five climatic zones. These five climatic zones[7] with a representative city and corresponding CDD are:

1. Hot & Dry (Ahmedabad, Gujarat; CDD_{18} of 3,514)
2. Warm & Humid (Mumbai, Maharashtra; CDD_{18} of 3,386)
3. Composite (New Delhi, Delhi; CDD_{18} of 2,881)
4. Temperate (Bangalore, Karnataka; CDD_{18} of 2,280)
5. Cold (Shillong, Assam; CDD_{18} of 287)

The factors that therefore will govern the energy usage inside the building can be classified as:

1. Energy consumption on the basis of climatic zones: Hot & Dry, Warm & Humid, Composite, Moderate, and Cold.
2. Energy consumption on the basis of building usage: Building Type
3. Energy consumption on the basis of conditioning: Conditioned and Non-conditioned buildings

However, bulk of the building population is in the hot & dry, warm & humid, and the composite climate zones. Appendix C presents a discussion on variability of energy use across climate zones as found through our sample data.

Equipment Penetration and Hours of Operation

Energy use in an establishment is driven largely by the number and type of energy using equipment in use and the hours of operation of the building. The study collected data on the types of cooling equipment in use and their nameplate efficiencies in the buildings

[7] Climate Zone Map of India is included in Appendix A.

surveyed. This data is useful in establishing baseline efficiencies for end-uses such as cooling. Table 3-2 below presents the cooling equipment shares in specific building types based on surveyed data.

Table 3-1 Cooling Equipment Shares by Building Type

	Offices	Schools	Hospitals
CUAC - air-cooled	9%		5%
WRAC+Splits	5%	5%	34%
Multi-splits+Cassette	5%	0%	0%
Air-cooled Chiller	6%		20%
Water-cooled Chiller	6%		20%
None	69%	95%	21%

3.2 *Equipment Characterization*

Air conditioning or space cooling and lighting are the top two energy end uses within the buildings sector. Space cooling, as an end-use, is significant also from the perspective that its saturation in the existing building stock is very low. Even with hot and humid climatic conditions, currently only about 30% of the buildings are cooled. With the changing construction practice, this percentage will likely go up significantly in the future. Studies have indicated that energy efficient lighting, air conditioning and electrical systems could save up to 20% of the energy used in existing buildings (Singh and Michaelowa 2004). In addition, some simulation studies also indicate that new buildings can save up to 40% of energy with design interventions and stronger building energy standards (BEE, 2007).

In our current analysis, we take a conservative approach to estimating savings potential. We consider only those efficiency measures for cooling and lighting end-uses that are commercially available and are cost-effective from a consumer's perspective. The cost-effectiveness of an efficiency measure is determined on the basis of a life-cycle cost analysis of a technology option using a marginal electricity rate. For the High-efficiency policy scenario, we pick the most efficient of the cost-effective options considered. Table 3-3 shows the efficiency options considered in the study and their cost of conserved energy, for cooling and lighting end-uses.

Table 3-2 Efficiency Options Considered for Cooling and Lighting

	% improvement over Baseline	CCE ($/kWh)
AC - WRAC-msplit		
	15%	$0.02
	22%	$0.05
	30%	$0.07
AC - cassette units and multi-splits		
	8%	$0.03
	18%	$0.06
	22%	$0.08
	42%	$0.13
AC - Air-source packaged cooling AC (11TR)		
	4%	$0.02
	6%	$0.04
	19%	$0.13
AC - by Air-source packaged cooling HP (11 TR)		
	8%	$0.10
	14%	$0.16
AC - Air-source packaged cooling AC (17TR)		
	7%	$0.01
	9%	$0.01
AC - Air-source packaged cooling HP (17 TR)		
	9%	$0.09
Lighting -Fluorescent		
F40T12/ES w/ mag bal	Baseline	$0.00
Hi-perf T8 w/ elec bal (3 System Lamps)	11%	$0.01
Max Tech (LED Replacements)	22%	$0.03
Lighting -Incandescent		
Inc GS	Baseline	
CFL Replacements	66%	$0.01
Max Tech (LED Replacements)	87%	$0.10

4. Results: Estimates of Efficiency Improvements and Scenario for Savings Opportunities in Public Sector Buildings

In this section, we report on the aggregate energy use intensity, which is calculated using the total energy use and floorspace area reported in the previous data section. This is followed by a discussion of the BAU and HE scenarios. The floorspace projections are common to apply to both scenarios. The HE scenario includes an improvement in energy efficiency of two end-uses – AC and lighting. The AC improvements are estimated for a subset of the equipment used for space cooling.

4.1 *Aggregate Energy Use Intensity*

The commonly used measure for assessing the energy performance of a building and for commercial end-use demand forecasting is the energy use intensity (EUI). Typically, energy-efficiency indicators for commercial buildings can be obtained by normalizing the energy use with floor area and/or operational hours. In this study we define EUI as the quantity of energy used per unit of floorspace. Climate adjustment of energy use data is performed when the degree-days information is available. By normalizing for primary determinants, the study utilizes the EUIs of existing building stock to calculate the potential improvement in the policy case for the new and surviving building stock. Figure 3.7 shows the range of EUIs found in the set of office buildings analyzed in this study. We see a relatively wide range in energy consumption (20 – 500 kWh/sq.m), which is indicative of several factors, including levels of space conditioning, lighting, and other internal loads. Currently about 30% of the buildings are cooled. This percentage is expected to go up significantly in the future. However, for the sake of simplicity, we keep this percentage frozen for the analysis period in this study.

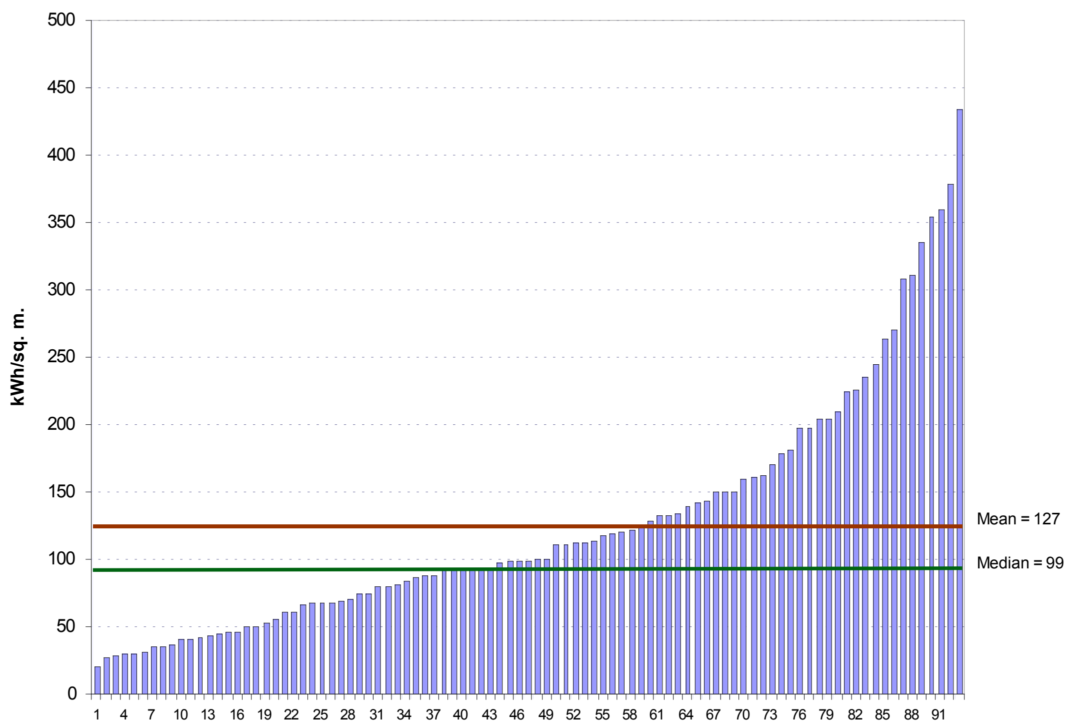

Figure 4-1 Energy Use Intensity (EUI) in Public Sector Offices

For estimating aggregate EUIs, we remove what we consider to be outliers from our building sample data[8]. Utilizing the building level energy consumption numbers, the study estimated aggregate EUIs for the whole building. Traditionally, median is used to appropriately represent the building sample in order to avoid biasing the estimates from

[8] The sample includes existing building energy data and LBNL's own survey.

being skewed towards very low or very high consuming fewer buildings. However, since we have a relatively small sample and evenly distributed set of buildings (with a balanced tail), we use the mean EUI as a measure aggregate EUI. Mean EUIs are also the appropriate measure when used to estimate consumption at the sectoral level. In order to further disaggregate the EUIs to specific end-use level, we had to rely on the combined wisdom of BEE energy conservation awards data[9], existing audits, and industry expert opinion.

Energy consumption in commercial buildings arises from diverse sources, and displays large variability. In order to provide a realistic assessment of efficiency potential, the study considers differences in end use consumption between distinct building types, and between new vs. existing buildings. The stock intensity is estimated simplistically, by taking an estimate of total energy consumption and dividing by an estimate of floor area by building type. For new construction, energy intensities are developed separately; generally, new building intensities are assumed to be higher, especially with regard to the presence of air conditioning. For developing the new construction EUIs, we use aggregate EUIs for new construction from the sampled building data, and scale it to adjust for non-proportional sampling and observed difference in calibrated versus sampled EUIs. The adjusted aggregate EUIs are presented in Table 4-1 and more accurately represent the entire population of both existing building stock and new construction.

Each of the end use intensity variables correspond to a multi-dimensional matrix over the following variables:

1. Building type
2. New vs. Existing Buildings
3. Efficiency Scenario

Our estimates for EUIs are detailed in the following table.

[9] These data are available online on the BEE website.

Table 4-1 Aggregate EUIs by Building Type and End-Use

New Construction EUIs (kWh/Sq.m)						
	Aggregate	Lighting	Cooling	Cooling Where Installed	Fans	Other
Offices	104	31	42	86	10	21
Schools	32	15	2	17	15	2
Hospitals	234	59	94	118	23	59
Hotels	158	39	87	102	0	32
Existing Stock EUIs (kWh/Sq.m.)						
	Aggregate	Lighting	Cooling	Cooling Where Installed	Fans	Other
Offices	61	18	25	78	6	12
Schools	26	12	1	26	12	1
Hospitals	137	34	55	69	14	34
Hotels	128	32	70	124	0	26

Note: 1. EUIs for existing building stock are calibrated to the official consumption data.
2. EUIs for New Construction are based on sample building data and adjusted to represent the entire population of new construction.
Source: Based on Sampled Building Data 2009

In addition to this disaggregation, intensity variables have a time dependency that parameterizes the evolution of construction trends and equipment markets, as well as the diffusion level of high-efficiency equipment as a result of government or market-based initiatives.

4.2 *Scenarios*

Floorspace Projections:

Figure 3-9 shows our forecast of floorspace in the public sector. These projections apply to both BAU and HE scenarios. The floor space stock in each year is the new floor space additions with retirements subtracted from the floor space in that year. Public Sector floor space stock is projected to increase from about 250 million sq. m to about 450 million sq. m. over the 2010-2050 period. Sectors showing the greatest increase in floorspace additions are large office, and healthcare facilities. We see that new offices and hospitals grow at approximately the same rate with schools and new “other” buildings following closely behind. The declining 2005 stock in the figure below is purely from the stock turnover. By 2030, new construction accounts for almost 50% of the total building stock in this sector, while it increases to almost 66% by the year 2050. This is by no means surprising as the construction sector has been growing at a consistent rate of 10% in the recent past, and the Planning Commission expects a similar growth pattern over the next five years.

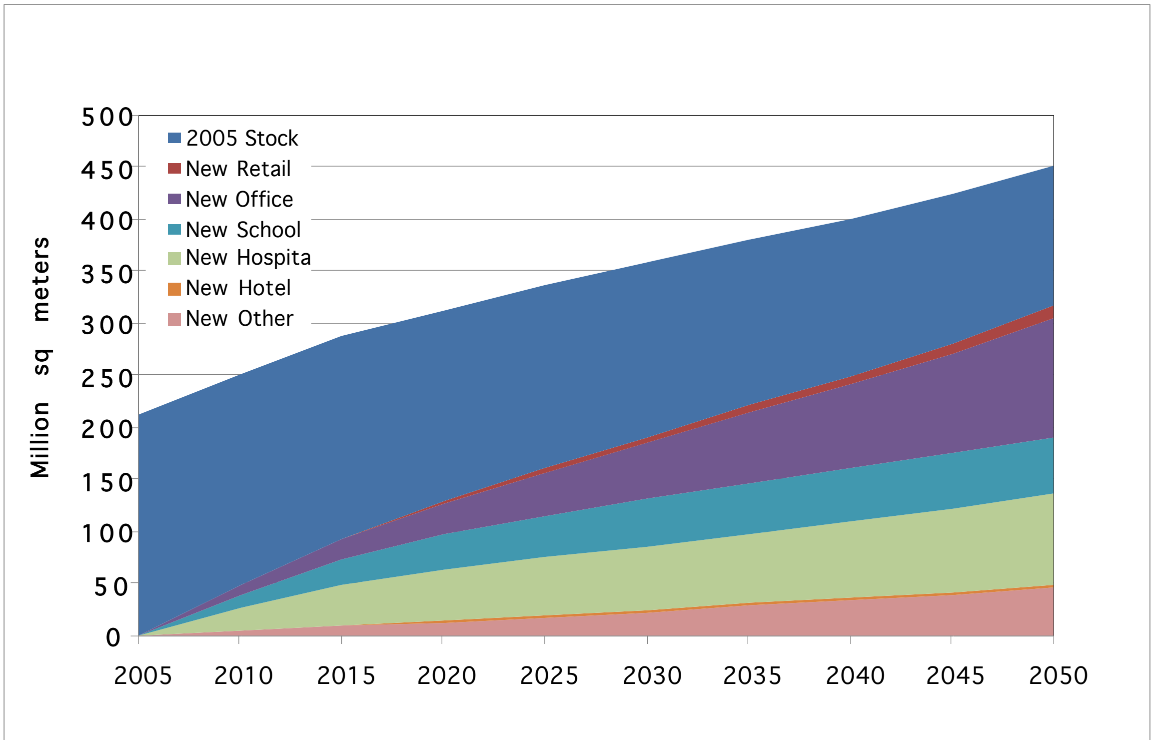

Figure 4-2 Floorspace Forecast of Public Sector Buildings

Energy Scenarios:

Both the Business As Usual (BAU) and the High Efficiency (HE) policy case scenarios assume an endogenous rate of improvement in the efficiency of the stock of around 0.7%. This rate is based on AEO estimates (AEO 2009). We expect the improvement rate to be higher for India considering the efficiency market is not mature. Although conservative, this rate does not affect the savings estimate, since it is applied to both scenarios. Our HE scenario considers efficiency improvements that are implemented to new buildings, with a technology adoption rate of 80%. The improvements are implemented through a decrease in EUIs for the end-use being considered. Improvements are applied only to that portion of the stock, which uses the considered technology. In the case of existing building stock, improvements are applied to that fraction of the stock, which would likely retire and turn over. The current analysis does not consider retrofits.

The following two figures present the forecasted site energy consumption by fuel type in the BAU scenario, and total electricity consumption in the two scenarios respectively. Energy consumption in the BAU case more than triples by 2030 and quadruples by 2050.

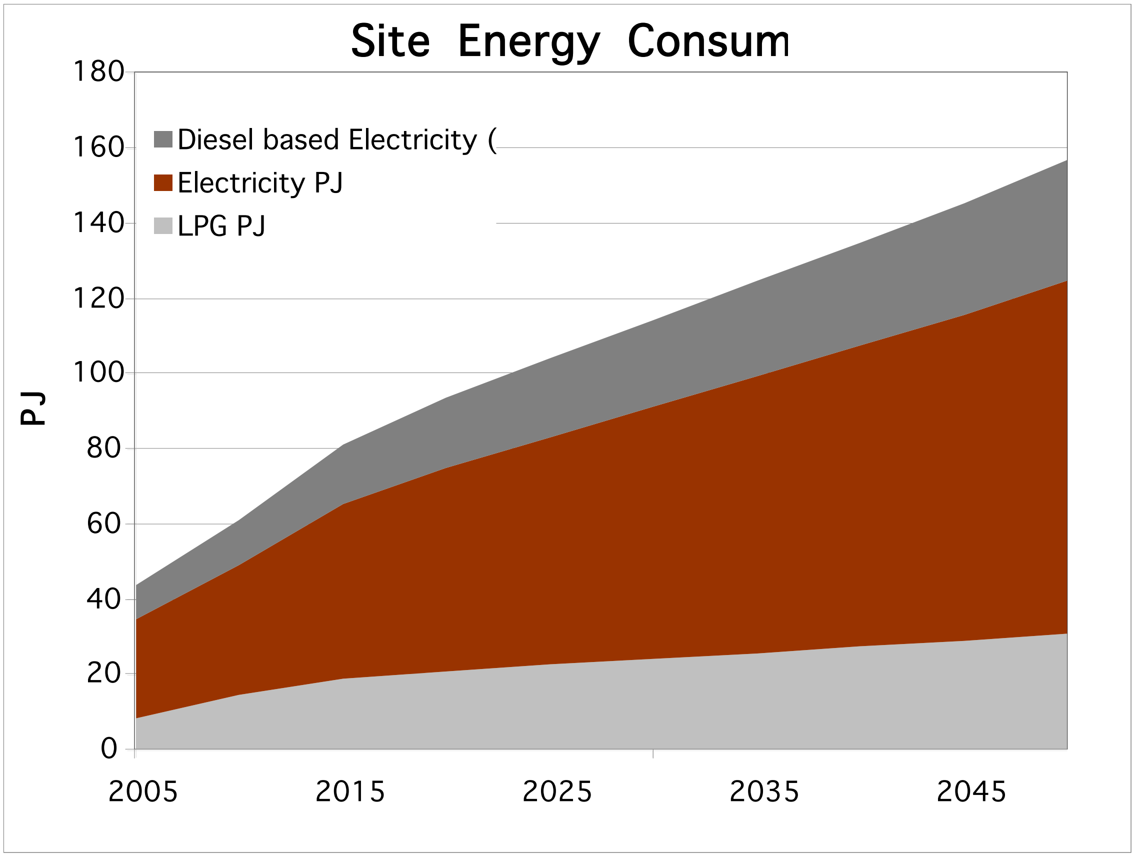

Figure 4-3 Public Sector Site Energy Consumption Forecast

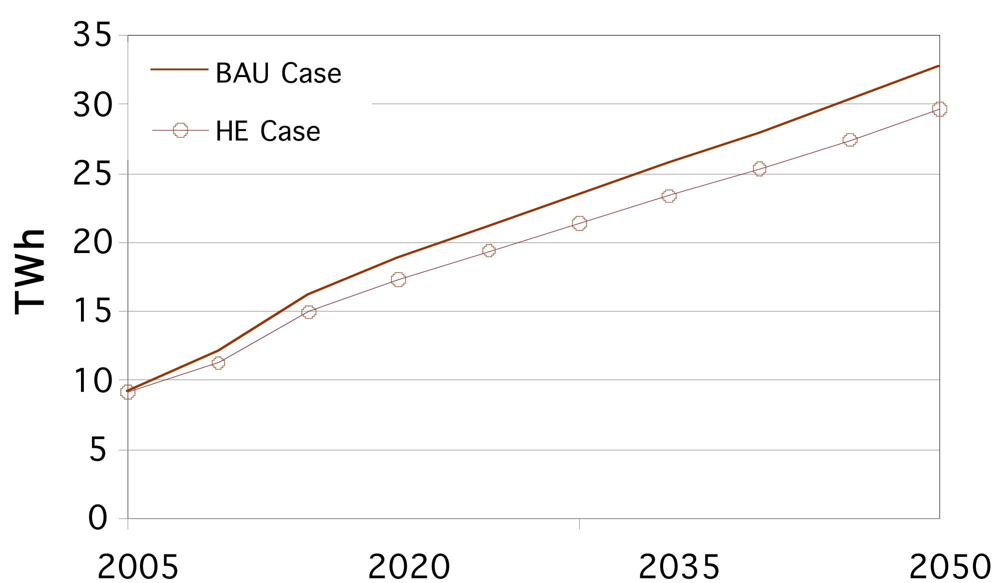

Figure 4-4 Public Sector Total Electricity Consumption Forecast

Carbon Emissions and Investment Scenario:

In this study, we build our scenarios around the cost of conserved energy and translate that into \$/ton of CO_2 saved. The premise for these scenarios is that in the short run, energy conservation mainly affects a utility's energy costs. In the long run, energy conservation may affect decisions about expanding generating and transmission and distribution capacity. Given the severe shortage of electricity generating capacity in the country, the impact of energy efficiency policies on decisions about expanding generating and load distribution capacity will be significant and may conceivably vary across the country. On average, however, the impact of such policies is sufficiently large to have an impact on capacity expansion. This situation supports the use of long run avoided costs to measure the impacts of energy efficiency measures. Determining the appropriate avoided costs at a national level for a future time period is not a simple exercise and is not dealt with in this study.

Figure 10 below presents the estimated CO_2 emissions for two scenarios considered in this study. The policy case or efficiency scenario takes a conservative approach to estimating savings. Based on our analysis, an annual emissions reduction of about 3 MT of CO_2 by 2050, which is a 9% reduction for the sector just from two end-uses. This amounts to a cumulative savings potential of about 20 MT of CO_2 over the period 2010-2020 and 80 MT of CO_2 over 2010-2050. The savings estimates are conservative accounting for select end-uses, limited data on current energy use and existing mix of technologies. Evidently better coverage of end-uses and exhaustive data on technologies currently in use would yield greater savings opportunities.

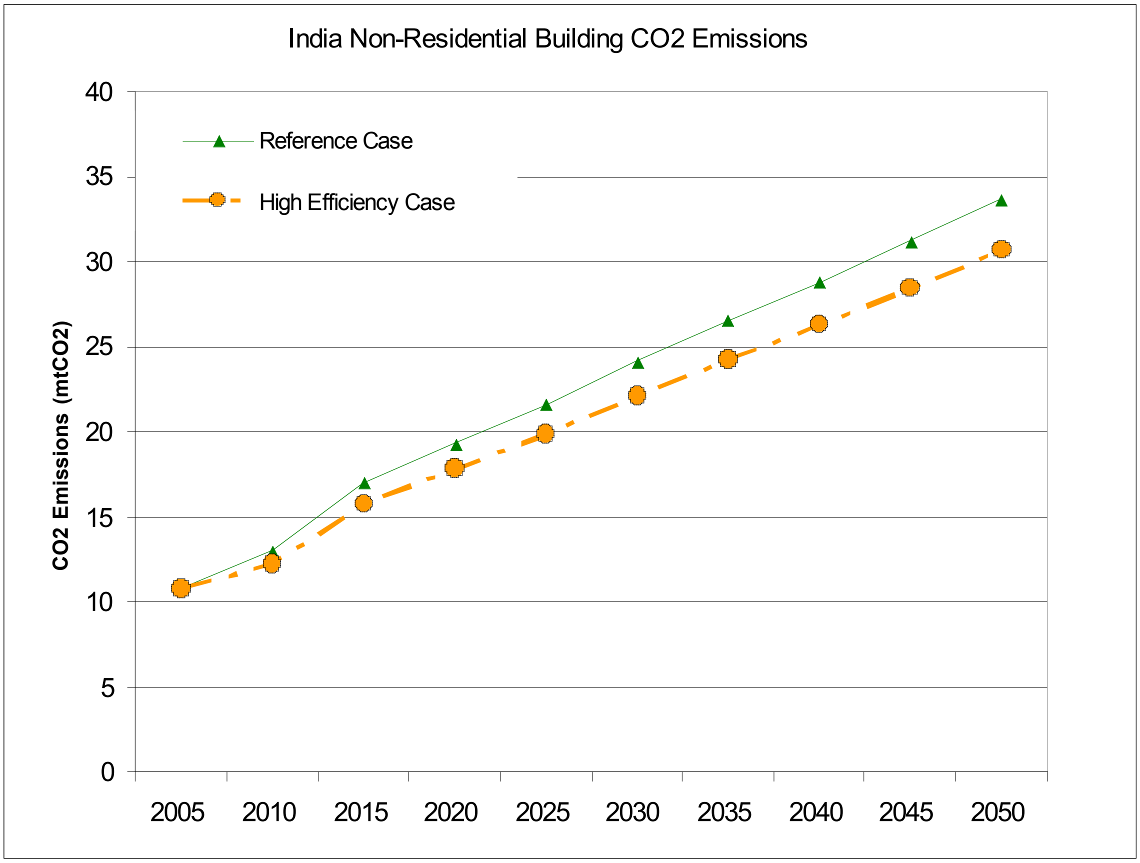

Figure 4-5 Public Sector CO_2 Emissions

Figure 11 below presents the financial impact of implementing the considered efficiency measures in this study. The measures considered translate into an annualized average cost of saving electricity (equivalent annual cost) of about $50 million/yr over 2010-2030 and about $100 million/yr, over 2030-2050 periods. These investments are based on an annual discount rate of 12%.

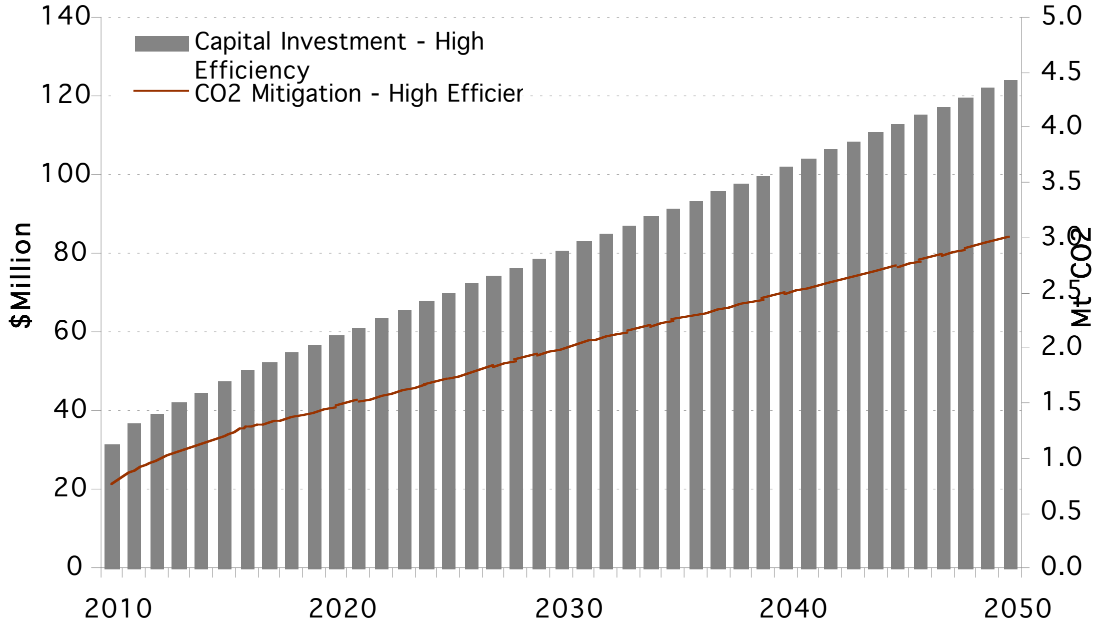

Figure 4-6 Estimated Capital Investment for HE Scenario

4.3 Data Limitations

One of the main limitations of the study is the lack of adequate data to accurately understand the existing building stock, technology mix and efficiency distribution of the installed equipment in the building stock. The floorspace estimation follows the simple logic of space utilization factors and the quantum of workforce for typical facilities engaged in a specific economic activity. These utilization factors are adjusted to as accurately represent the Indian conditions as possible from the limited data and studies available. Our building stock estimates could have a ±10-15% uncertainty, contingent upon variability across establishments within an economic activity category. To maintain integrity to our energy use and thus savings estimates, we calibrate all our energy use metrics to the official energy consumption data. While the current study makes a significant attempt to get around the data limitation to assess the existing building stock through alternative means, systematic and regular data updates are essential to monitor and study energy consumption trends.

From a policy perspective, the effectiveness of investment in energy efficiency is contingent on the availability of reliable end-use data for buildings, availability of information rich databases such as CBECS, and analysis tools that accurately estimate cost-effective savings from implementing specific efficiency measures. Currently, dedicated collection of energy use information is not prevalent either at the national level or at the state level. Nevertheless, the growing momentum to build green and to benchmark buildings makes systematic data collection necessary. At a macro level, the

Construction Industry Development Council (CIDC) produces construction statistics every couple of years. These could be improved through regular updates and greater disaggregation.

5. Possible Paths for Refining Public Building Energy Use Information

Energy and buildings information is regularly collected through statistical surveys for the residential sector by the Central Statistical Organization (CSO) of the Ministry of Statistics and Program Implementation. It may be most appropriate for CSO to integrate data collection on building characteristics in their existing consumer surveys and the basis to develop a statistically sound process for periodic data collection on publicly-owned buildings

The current study has compiled data on 130 public sector buildings spread across different climate zones and building types. Although it is a good start, and helps estimate aggregate EUIs, data at end-use level is very sparse and limited. The representative building set is not large enough to produce statistically robust estimates of aggregate EUIs. LBNL collaborated with key public sector organizations and the ECO-3 project office in Delhi in this significant initiative. LBNL has also established links with architectural and mechanical design firms to provide important information on current building practices. Some of these firms collected valuable building use data for the study. It will be useful to solidify this effort by building on this study and improving the quality of the estimates by expanding the dataset and collecting end-use level data. We provide a data template for data collection in Appendix B, which was developed in collaboration with the ECO-3 project office in Delhi.

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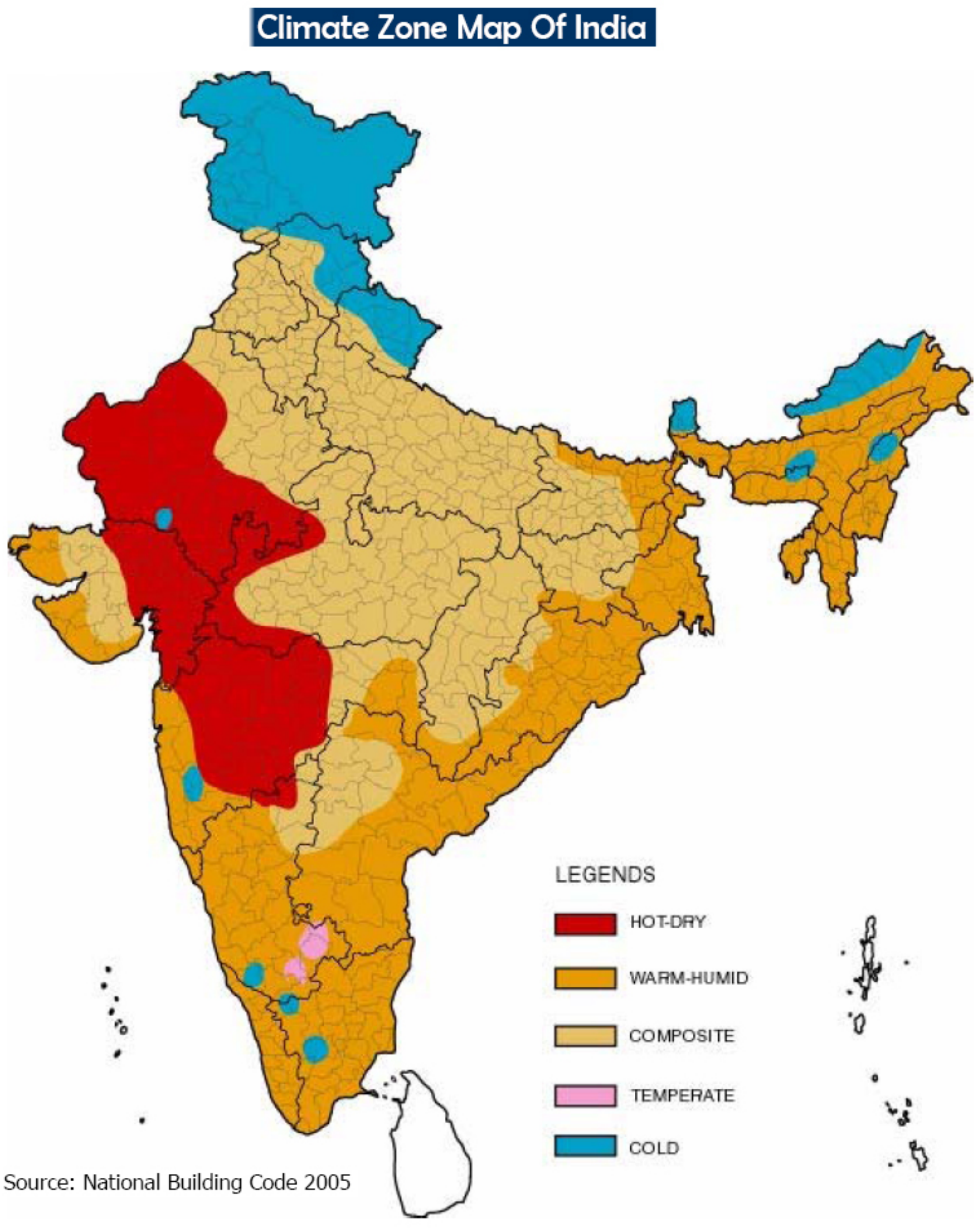
Appendix A: Climate Zone Map of India



Appendix B: Data Collection Template

Data Collection Template developed in Consultation with ECO III project office

Name of the Building: City:

Building Information and Energy Data

<table>
<tr><th colspan="3">Primary Data</th><th>Year:</th></tr>
<tr><th>No.</th><th colspan="2">Item</th><th>Value</th></tr>
<tr><td>1</td><td colspan="2">Connected Load (kW) or Contract Demand (kVA)</td><td></td></tr>
<tr><td>2</td><td colspan="2">Installed capacity: DG/ GG Sets (kVA or kW)</td><td></td></tr>
<tr><td rowspan="3">3</td><td colspan="2">a) Annual Electricity Consumption, purchased from Utilities (kWh)</td><td></td></tr>
<tr><td colspan="2">b) Annual Electricity Consumption, through Diesel Generating (DG)/Gas Generating (GG) Set(s) (kWh)</td><td></td></tr>
<tr><td colspan="2">c) Total Annual Electricity Consumption, Utilities + DG/GG Sets (kWh)</td><td></td></tr>
<tr><td rowspan="3">4</td><td colspan="2">a) Annual Cost of Electricity, purchased from Utilities (Rs.)</td><td></td></tr>
<tr><td colspan="2">b) Annual Cost of Electricity generated through DG/GG Sets (Rs.)</td><td></td></tr>
<tr><td colspan="2">c) Total Annual Electricity Cost, Utilities + DG/GG Sets (Rs.)</td><td></td></tr>
<tr><td rowspan="5">5</td><td rowspan="5">Area of the building (exclude parking, lawn, roads, etc.)</td><td>a) Built Up Area (sq. ft. or sq.m.)</td><td></td></tr>
<tr><td>b) Total Carpet Area (sq. ft. or sq.m.)</td><td></td></tr>
<tr><td>o Conditioned Area</td><td></td></tr>
<tr><td>o Non Conditioned Area</td><td></td></tr>
<tr><td>c) Non-active Carpet Area* (sq.ft. or sq.m.)</td><td></td></tr>
<tr><td>6</td><td colspan="2">No. of Floors in the building</td><td></td></tr>
<tr><td>7</td><td colspan="2">Working hours (e.g. day working /24 hour working)</td><td></td></tr>
<tr><td>8</td><td colspan="2">Working days/week (e.g. 5/6/7 days per week)</td><td></td></tr>
<tr><td rowspan="8">9</td><td rowspan="2">a) Office</td><td>Total no. of Employees</td><td></td></tr>
<tr><td>Average .no. of Persons at any time in office</td><td></td></tr>
<tr><td rowspan="2">b) Hotel</td><td>No. of Guest Rooms</td><td></td></tr>
<tr><td>Guest Overnights in the year (% Occupancy)</td><td></td></tr>
<tr><td rowspan="2">c) Hospital</td><td>No. of Patient Beds</td><td></td></tr>
<tr><td>Patient Overnights in the year (% Occupancy)</td><td></td></tr>
<tr><td rowspan="2">d) School</td><td>No of Students and Teachers</td><td></td></tr>
<tr><td>Average number of Students + teachers + staff in the year</td><td></td></tr>
<tr><td rowspan="4">10</td><td rowspan="4">Installed capacity of Air Conditioning System</td><td>a) Centralized AC Plant (TR)</td><td></td></tr>
<tr><td>b) Window ACs (TR)</td><td></td></tr>
<tr><td>c) Split ACs (TR)</td><td></td></tr>
<tr><td>d) Total AC Load (TR)</td><td></td></tr>
<tr><td rowspan="3">11</td><td rowspan="3">Efficiency of Air Conditioning System</td><td>a) Centralized AC Plant (EER/COP)</td><td></td></tr>
<tr><td>b) Window ACs (EER)</td><td></td></tr>
<tr><td>c) Split ACs (EER)</td><td></td></tr>
<tr><td>12</td><td colspan="2">Installed lighting load (kW)</td><td></td></tr>
<tr><td>13</td><td colspan="2">Whether sub-metering of electricity consumption for Air Conditioning, Lighting, Plug Loads, etc. done: Yes/No</td><td></td></tr>
</table>

14	Fuel (e.g FO, LDO,LPG, NG) used for generating steam/water heating in the year (in appropriate units)	
15	HSD (or any other fuel oil used, specify)/Gas Consumption in DG/GG Sets (liters/cu. meters) in the year	

* Portion of Total Carpet Area (e.g. auditorium, seminar halls, large conference rooms, etc.) which is not used actively on daily/regular basis and normally AC systems/lights are kept switched off.

Contact Details of the Organization and the Contact Person

No.		Details
1	**Organization**	
a)	Name of the Organization	
b)	Postal Address	
c)	Phone No.	
2	**Contact Person**	
a)	Name & Designation	
b)	E-mail Address	
c)	Phone Nos.	

Appendix C: Energy Use Across Climate Zones

The figures below present the spread of EUIs across climate zones for office buildings. We use two measures to assess the variation across climate zones. We calculate aggregate EUIs (these are equal to the total energy use divided by the total built-up area) and conditioned EUIs (these are equal to total energy use divided by the conditioned floorspace). It is important note that although there seems to be some variation between cold, temperate and the remaining three climate zones, the sample points are not enough to provide conclusive results. The temperate zone, for instance is grossly under-sampled. However, if we analyze the EUIs across the remaining 4 climate zones, it is clear that there is not a significant variation between warm-humid, composite, and hot-dry regions. The cold region, however, shows a lower EUI than composite, hot-dry, and warm-humid zones. Since EUIs based on conditioned space more accurately represents energy use intensity, we plot these data across climate zones. A similar pattern can be observed when comparing aggregate EUIs with conditioned EUI. For the purposes of our analysis, we do not model consumption at a regional level. We estimate end-use energy consumption at the national level.

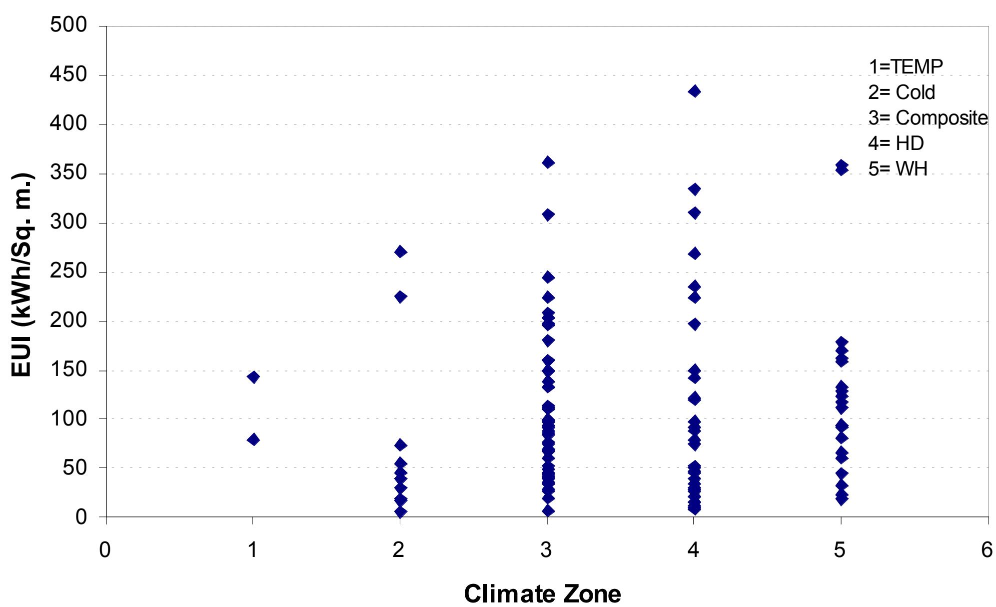


Figure C-1 Energy Use Intensity of Offices in the Public Sector

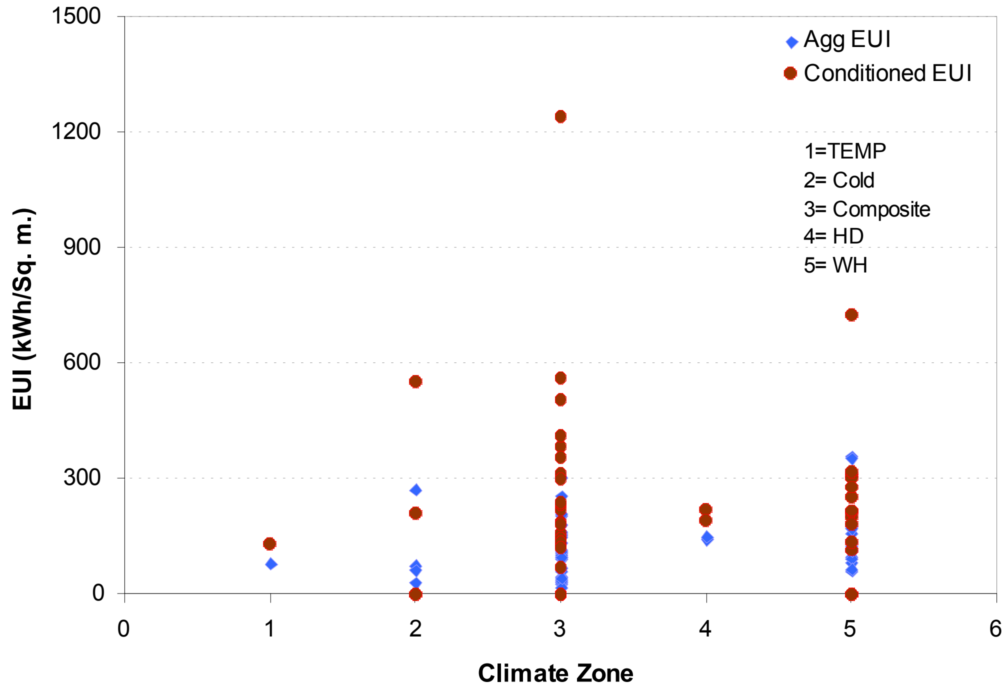


Figure C-2 Aggregate and Conditioned EUIs in Public Sector Office Buildings

Although the figures above show EUIs ranging from less than 10 kWh/sq.m to over 400 kWh/sq. m. (and 1200 in the case of conditioned EUI), we plot these only to show the variation in the data collected.